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THE CULTURAL VALUE OF ENGINEERING EDUCATION.*

BY FRANK O. MARVIN.

What is culture? The writer has been asking this of his friends. An answer has been sought for in the printed page where is recorded the best thoughts of the best minds. Great thoughts and lofty ideals have been disclosed, but nowhere has been found a satisfactory definition, a phrase or paragraph that succinctly and clearly sets forth the heart of the matter.

People often recognize, appreciate and reverence its possession without being able to fully analyze and set down its elements. There is something subtle and emotional about it that eludes a close pursuit.

The reason for this perhaps lies in its essential individual quality, in its being the result of a personal life, developed, it is true, on lines similar to those used in other lives, yet including something that pertains exclusively to the human unit that is different from all other units.

Nevertheless, there seems to be certain fundamental qualities which must be possessed before a man can be classed with cultured people, qualities which are only acquired after a considerable experience in life, but which are influenced greatly by the years of student training. Far be it from the purpose of this paper to attempt a definition of culture or a setting forth of its elements in any completeness; rather the emphasizing of some things that

*Abstracted from an address of the President of the Society for the Promotion of Engineering Education, Buffalo meeting.

relate to it, especially with reference to the education of young engineers.

1. The man of culture must be a thinking and reflecting being. There must be not only the ability, but the habit; and this is no easy thing to acquire. Modern American life is full of hurry, full of affairs that demand instant attention, and one matter follows another with rapid succession. Men seek short cuts to fortune. In the popular opinion, the men who act quickly, the men of decision, are those who succeed. But there is a danger here. For, back of the action, behind the sharp decision, must lie a mature judgment, and how else is this to be formed except as a result of deliberate reflection. However quickly one may reach a conclusion, its correctness or faultiness will depend not on intuition, but on the degree of true comprehension. The decisive act which is also right rests on a process of thinking and judging that has been long fostered until it has become a habit, until there are established certain standards by which things are to be measured.

The early steps of this training are necessarily slow, and we, as teachers, must recognize this and not yield to the temptation to crowd our students over too much ground on the one hand, or, on the other, to lead them through short cuts across country by empirical paths that may give them ease and quickness of travel, but little or no reason why the path is chosen. Let them go the long road. I do not by any means wish our teaching to be non-practical—rather more practical in the best sense; but first, last and all the time, let students be trained to do their own thinking and to form their own judgments; to test the statements of others by the workings of their own mental processes.

2. There is another element of culture that comes in here, an ethical one—that of forming right judgments. Men may have the appearance of culture without its true spirit, which is essentially honest. This is especially important, as culture seeks to make a man's life satisfactory to himself when measured by his own conscience, as well as successful in the field of affairs. So his standards must be based on sound principles of right and wrong; and it is only when these are so placed that his life becomes one of freedom, freedom from the bondage that wrong

thinking and acting always bring. A class room is no place to preach a sermon, but there can be there imparted a respect for truth and perfect honesty. A teacher's attitude should always be open and frank, that of a sincere seeker after truth. He should never dodge an honest question, and be ever ready to say "I do not know," if he does not. There is an incalculable power that "makes for righteousness" and the happiness of the after life of the student in the true teacher's conduct of even such a material subject as mechanics.

Back behind the subject, with its subdivisions, its formulae and rules, lies something larger, a sort of spiritual quality that binds it to all other subjects, to the universe as a whole, and makes it a part of the truth of God's realm. The student that gets hold of this significance learns much more than facility in the manipulations of processes or the application of principles. He gets something that makes his life richer and better and his mastery of the subject more complete.

3. There can be no true culture for a man that does not work, that does not put his cultivated powers to some useful service; and here there must be such degree of mastery over the chosen profession or business as will result in a special skill and dexterity—a doing of some one thing better than others can do it. A man expresses himself through his work, and whether he will or no, he thus discloses to all who know him his own peculiar qualities. It is this intensity of application, this concentration of purpose and directness of aim, that gets the world's work done. Here in early years the engineering student has the advantage of the student in arts. Study for knowledge's sake may be stimulating to the few, but for the many there is needed the goal of a special calling to secure the close application that results in ability to concentrate one's energy to the attainment of a certain end. But here again comes a danger, that of too early, or over, specialization, and the following of short cuts to professional life that are advocated by some who, in the eyes of the world as well as in their own, have been eminently successful as specialists. Whether these can be called men of culture of the highest attainments is another matter. The extreme specialist may be supreme in his own line of details, but may fail when there comes

up a question involving the relation of his specialty to other things. Even within his own domain, his conclusions will be modified by his general knowledge and experience. All one-sided people, whether they be linguists or naturalists, poets or merchants, preachers or engineers, are quite liable to the forming of erroneous judgments. To the few geniuses whose capacities and powers seem to be abnormally developed, though of limited scope, much is forgiven; but for the average man of the day there is demanded an ability to form good and wise conclusions.

4. In order to form those that are appropriate and correct there is needed, then, breadth of view—a quality that has been expressed by the word “poise.” A man of poise, of even balance, will see things in their right relations and due proportions; he will weigh matters, giving to each component part its just degree of importance. He will the better understand the motives that underlie other men’s actions and the more readily use them to suit his own purpose. He will be more apt to rightly interpret the new movements in the world of thought or action and can seize opportunity for a personal advantage or a larger sphere of service before others see that there is such.

This demands a considerable range of knowledge. Not the close mastery of many lines in all their details, but a fair degree of familiarity with their general phenomena and principles; and there is scarcely any field that will not contribute something to the result. It is admitted at once that the average man is of limited capacity and unable to grasp a comprehension of all knowledge that may influence his life and work; what is pleaded for is such degree of breadth as may be needed to make one of great efficiency in his chosen profession and of most value to himself, not only in a financial way, but also in the sense of gaining a joyful recognition of the worth of developing all the powers that one has.

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5. It is not sufficient to form correct judgments only; there must be added a skillful and effective presentation of them in well-chosen and fitting English. The ability to do this involves more than training in the writing of compositions, themes, forensics and reports. The cultured man should have a taste for read-

ing the best that has been written in his mother tongue, and for several reasons: The great thoughts of great minds are stimulating and broadening to his own mind; he thereby absorbs a knowledge of words and their shades of meaning; he gains an appreciation of style and insensibly better knows how to form his own; and, not least by any means, he makes of his books friends that are life-long, that cheer and console him under all happenings, adding much to his internal resources for happiness.

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6. To the writer's mind, there is another element of culture that should enter into an engineer's training, viz., an appreciation for beauty. The engineer is a designer, and it is important that he should embody his design in artistic form if he is to fulfill his whole mission and please and gratify others by the perfection of his work. The engineering student devotes a good share of his time to the drawing-board, and much can be done here toward the cultivation of this quality by an instructor who possesses it, without lessening at all the amount or force of the technical exercises for which the process is primarily used. There should be, however, something further by way of giving instruction in elementary æsthetics and by opening the students' eyes to what is beautiful in nature.

7. The possession of agreeable manners and tact is another evidence of culture, not merely the conventional bearing of polite society, though this has its value. This alone is but a husk which must cover the real kernel, refined and gentle feeling; and such feeling is the result of moral and intellectual convictions. Manners, then, are not to be taught from a text or by lecture; they rather follow as a consequence from the whole course of training, and are crude or refined just as the character of the instruction makes them. The teacher's personality has very much to do with this matter. If he is of coarse grain, of domineering or selfish disposition, his influence will not tend toward the production of true gentleman. And now for the real question—does engineering education tend to produce culture? According to old standards, when men limited culture chiefly to a knowledge of language, literature and philosophy, the reply would be in the negative. However, standards are not the thing itself, only methods of

measurement; moreover, standards change. Science has modified and is still changing the ideas of culture that men hold, and this evolution makes it all the more difficult to find a common ground upon which all can stand when considering things concerning it. This much is clear, however, that no one existing course of educational training has a monopoly of cultural methods; nor will the college course necessarily secure its attainment because of its personal quality. Further, culture is the result of a life, and the most that can be expected of a college course is to open the students' eyes to its real worth, to start them rightly with certain leanings and aptitudes, and furnish them with the means of a continuous growth toward its maturity.

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Herein lies our responsibility.

"KEEPING THEM DOWN."

BY EDWARD F. BIGELOW.

Stamford, Conn.

"Well, I suppose that is all right, but please tell me how I am going to get them down again?" she said in a low tone to the superintendent, as I went out of the school room. The words were not intended for my ears, but I caught them, and they touched me, every bit of me.

She was a teacher who thoroughly believed in discipline. Every action in the school flavored of militarism. She was famous throughout the town for her good government. When the superintendent and I entered the room she came forward very primly (and I thought grimly—but perhaps that was imaginative, the result of the casual remark of the superintendent, "You will have to be a little careful with this teacher. She is great on discipline and routine and says that she doesn't believe in modern fads." The good old methods of the days when Webster's blue-covered spellin' book was paramount were good enough for her.)

After acknowledging the introduction, she turned and said:

"Now, children, this is Mr. Bigelow. He knows everything about the trees, and flowers, and birds, and bugs, and such things, and he has come here to tell you all about them. (A large contract, I thought.) Lay aside your books and papers; now sit up and fold your arms and pay strict attention. You must be very still. He is going to talk for three quarters of an hour, and he will tell us a great many interesting things, I am sure."

After a minute or two made noisy by the putting of books into desks, one could almost painfully hear the *tick-tock* of the clock. The teacher turned to me, and, as she nodded her head, said:

"Now, Mr. Bigelow."

Then she went to the opposite corner and stood there with eagle eye wide expanded to detect the earliest sign of disorder. In the meantime she had sent an assistant to the rear of the room. I paused for a moment to enjoy the air of expectancy and the almost breathless stillness. I noted the glistening eyes of a few, and the soldier-like indifference of most of the pupils. Three or four big boys in the rear seats had especially attracted my attention, by the look, half of disgust, half of protest with which they had swung books out of sight, and stuffed their hands into their pockets. I had seen that look before! I knew how to translate it into "Oh, this is going to be a goody-goody talk telling us how we ought to enjoy this beautiful world and be very gratefully to the One that has given it all to us, etc." With an air of resignation, they leaned back, and I remembered the factory that we had just passed, and what the superintendent had told me of the dull work, the long hours and the low pay of the operatives.

Then I said:

"I'm trying to find out how young folks feed their pet animals. Will some one please tell me what he thinks is the best for his especial pets? A friend of animals has written to me that bread-and-milk should not be fed to any pet animal, and I am trying to learn about the experience of others. Will some one please speak and tell me?"

Simple as this inquiry was, it had the effect of a bomb shell. The mental attitude was completely upset and I had to wait a minute for it to settle. Here was every one, other than myself,

expecting a sermon on the wonders and beauties of nature. The young folks had from earliest childhood been told and told again, with so much of line upon line and precept upon precept, that I felt almost culpable as I thus jerked their minds "the other end to." They to give information and I to be the learner! Impossible! It took a minute for the idea to penetrate, for the hands to come out of the pockets and the legs to be drawn up, while looks of astonishment passed from one to another. Faces brightened, eyes began to sparkle, a hand here and there came up hesitatingly. I had touched the known in a place dear to the hearts of those young people. The matter of food was soon explained. Then what stories of dogs, cats, parrots, canaries, hens, rabbits, and even of a pet crow. The story of this crow's capture led to an experience related by one of the big boys about his dog and a woodchuck killed in the stone wall and how the little woodchucks were brought home. I was delighted; the superintendent's countenance beamed with pleasure—I saw that he was convinced—and later I was not surprised to have him write to me, "We have room for the kind of Nature Study you exemplified." But the teachers were alarmed—almost excited. The eagerness of some of the children to tell experiences actually pushed them out of the seat and several steps forward with outstretched hand. Oh the joy of telling! the joy of being appreciated, of being recognized as actually knowing something worth listening to! Every mind woke up, because each was appealed to individually and every one eager to respond. The assistant expressed volumes when she whispered to me as I shook her hand in parting, that she "didn't think that those children knew so much."

But the principal apologetically said to me, "Why, I never saw them act so badly. I'm afraid you'll think we don't have any order. I was ashamed to have two or three talking at once."

To her I said, that they had been only a little over-eager in telling me their experiences. But to you I say that I commend the young folks. I regretted that there was only one opportunity of telling, that there must be a condensation of what should have been extended.

The principal then made the remark to the superintendent, as already quoted, at the beginning of my article.

O principal, and perhaps you, O teacher, who read this. Discipline, instruction are for your school, as a whole. Nature study is for the pupil—this one, that one—a recognition and development of individuality. Restrain *and* develop. Let me repeat; not one, but both. Not everlastingly keeping them down but sometimes letting—helping, encouraging—to spring up. That is why I appeal to you for informal "Nature Study," for the very young folks, not instruction in science, however elementary, dilute or interesting you are able to make it. For when it comes from you, it is in the keeping down, the filling up. Think and do sometimes from the child's standpoint. That in relation to natural objects is "Nature Study." Let it spring up in eagerness—waking up the whole child life.

BIRD STUDY IN OUR COURSES IN ZOOLOGY.

BY GILBERT H. TRAFTON.

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To the use of the college method of dissection in our elementary courses in zoölogy, often employed by the newly made graduate, there is widespread objection. This objection is implied and a positive statement made of the substitute to be used in such books as Jordan and Kellogg's "Animal Life," The writer believes that books of this class will revolutionize the teaching of elementary zoölogy and mark an epoch in its history. The plan of this book, together with its companion, "Animal Forms," closely parallels the course now generally recommended in botany, the first half year being devoted to the ecology and general problems of plant and animal life and the second half year being occupied by a study of types.

Ecology, which occupies an important place in this modern spirit of zoölogy, may be defined as the relation of animals to their surroundings. One of the most important features in these surroundings is the human element, so that the mutual relations of animals and ourselves form an important phase of this subject;

and when these relations prove to be of vital interest to the human race, special reason is furnished for their consideration. Such conditions are found in our relations with the birds. It is not the purpose of the writer to enter into any discussion of the economic value of the birds, the proof of which is furnished by the mere reading of the facts in the case. Professor Frank M. Chapman, one of our greatest ornithologists, writes: "Reference to the works and papers mentioned will support the statement that, if we were deprived of the services of birds, the earth would soon become uninhabitable." The matter is of such importance that the United States Department of Agriculture has formed a Division of Ornithology, which has made a most careful study of the relations of birds to agriculture, a study which has proved their inestimable value. But at about the time that we were beginning to learn with some certainty that the agricultural interests of the country are bound up closely with the work of the birds in destroying injurious insects, our attention was called in a startling manner by Mr. Hornaday, to the rapid decrease and threatened extinction of our birds.

In consideration, therefore, of the fact that the threatened extinction of our birds would have an effect on the food supply of the human race, the very contemplation of which would make us stand aghast, and in consideration of the further fact that this alarming decrease of bird life can be checked and the threatened disaster to the human race avoided through the education of our youth, should not, at least, as much bird study be included in our courses in zoölogy as is suggested by the following topics: The economic value of the birds; the amount and causes of their decrease; the remedies that may be employed to check this decrease, and an acquaintance, by means of field study, with, at least, a few of our common birds as a means of personally interesting the students in the birds and their protection, as well as furnishing a constant source of enjoyment through all their life.

In this connection, an exercise that will prove of value in a few years in determining the decrease or increase of the birds in a given locality, is to have the class take a census of the birds

within a certain area. This can best be done by counting the number of nests found just after the leaves fall, a plan first suggested, I believe, by Mr. Chapman. The results may be kept on record and serve as a basis for comparison for future censuses, from which valuable information may be obtained regarding the change in the number of birds.

Science has come to occupy a place of increasing importance in our curricula, partly because, while other subjects which it is displacing, having furnished the disciplinary factor in education, failed on the practical side, the sciences may be made to fill both these needs. In the subject under discussion is an opportunity for zoölogy to prove its practical value and to serve the people.

That some of the work suggested should be, and to some extent is done in nature work in the grades is true. But the proper relation of high school science to nature work in the grades is not to avoid the subjects taught there, but to use the facts learned there as the basis for a more complete discussion of the subjects involved. But inasmuch as many of our common schools still give no place to nature study, and as the exigencies of the case demand immediate action, additional strength is lent to the claim that economic ornithology should receive attention in our high schools. Some of the grades below the high school are coming to recognize the value and necessity of bird study; some of the grades above the high school, the colleges and universities, are recognizing its importance. Shall not the high school take its place in the chain?

Aside from the economic standpoint, the study of birds furnishes excellent training in accurate and rapid observation. And as each year introduces me to new students, I am surprised to find how little they see and am impressed with the need of giving them training that will develop their power of observation.

Nor should another feature be overlooked. An acquaintance with the birds, even though it be but a slight one, tends to develop the humane side of our natures and to give us more sympathy for all our wild cousins of nature, towards whose destruction and extinction man has done so much. And does not this touch upon the primary end of education, which is the development of character?

Bird study has a practical value in showing the great benefit of birds to man; it has an educational value in training the powers of observation; it has an aesthetic value in furnishing a lifelong source of pleasure; it has a moral value in broadening our sympathies. Do not these considerations entitle it to a place in the zoölogy courses of our secondary schools?

A HIGH SCHOOL COURSE IN BOTANY.

BY RUTH MARSHALL,

Ryan High School, Appleton, Wis.

The half-year course in botany here described is preceded by a course of equal length in human physiology. This latter study is given seven periods a week, so that two double periods are secured for laboratory work. The review in physiology just before the completion of the subject begins with the question: "What can the human body do?" The various activities of the body—movement, digestion, absorption, circulation, respiration, assimilation and disassimilation, excretion and response to environment—are thus given prominence, and each forms a separate topic for review.

When the same pupils (second year) begin the second semester with botany this same outline is used as a basis for the new study. The word "animal" is substituted for "human body." Then opposite this outline is given the question: "What can a plant do?" It has the power of movement, but to a less extent, and hence the expenditure of energy is less. Pupils have learned in the course in physiology that the source of all foods is green plants, and they now add a second activity, food-making. And so they go on through the list of activities, comparing the plant and the animal, reaching also the idea that both organisms differ from minerals in power to grow by assimilation.

These plant activities now form the basis for a month's work in plant physiology. Several simple experiments are introduced in the laboratory periods of which there are three double ones each

week. The pupils take such notes as they find useful to themselves with the aid of a blackboard outline developed as the class proceeds. A good deal of attention has been given to the subject of taking of notes in the previous course, and now they take them without supervision.

After this short course in plant physiology, five or six weeks is given to the study of typical cryptogams. *Pleurococcus*, *Cladophora* and *Fucus* for the Algæ, *Yeast* and *Mucor* for the Fungi, *Marchantia*, a moss such as *Polytrichum*, and the *Polypod* fern are the plants usually selected for laboratory work. Related forms are discussed in the quiz periods. The plant activities, and the role which each group plays in the world, are emphasized more than details of morphology. This work brings the class to the end of the winter term.

With the opening of the spring term field work is made a prominent feature. The aim here is to make the pupils familiar with the common plants of the locality. One double period each week is usually taken, and different places are visited. There will first be a trip about town to identify the trees; at another time fungi, algæ and lichens may be the subject; later a trip is taken on the street cars to Lake Winnebago to study hydrophytes. Sometimes mimeographed directions are given the pupils, and reports on this work are expected in a later class period. The collections made form the basis of the laboratory work. Harmful and injurious plants must be known. The flowering plants as they appear are noted; a few are studied superficially, with special reference to the relation of flowers to insects. To aid in their identification a little time is taken to show each member of the class how to use a key to analyze plants. To this extent plant analysis is justifiable and indeed a great help in the study of plants. Those pupils who have a taste for it are encouraged to make herbaria, and it might be well to give them credit for this. Last year a prize was offered for the largest list of flowering plants and ferns native to the county. It is hoped by the efforts of successive classes to get a fairly complete flora of the region. This field work is of course fascinating to both pupils and teacher and keeps the subject new and fresh.

The formal laboratory work in the spring term is the study

of one or two flowering plants in detail from the seed. The bean and the corn are convenient. Some lessons in practical agriculture are given; the seeds, planted and cared for by the pupils alone are grown in the laboratory, and the young plants are the principal material for the study. Many of the pupils keep gardens at home.

One of the short periods each week throughout the course is given to ecology, using the chapters in Barnes' "Plant Life" as a text. The rest of the book is used as a laboratory guide and reference. The school library is fairly good, containing most of the new elementary botanies, and each pupil has the use of one of these most of the time. The other short period in the week is often taken for reports on this outside reading, and the recitation this day is always the best. Near the end of the course the life of Darwin is given, and the theories of evolution and natural selection are explained. When the final review comes, the subjects are viewed from this new standpoint, that of development.

For an elementary course in botany such as this one, the teacher must insist upon having certain conditions. The laboratory, or some small room adjoining it, must be suitable for growing plants. For some experiments, such as those showing plant movements, the plants must be started some time before they are used, and the exercise may need several days. Much of the material for the study of type plants must be living. Spores of ferns and lower forms should be grown, and wild plants should be brought in early in the spring that their development may be watched.

Besides a suitable room, there must be three double periods a week for laboratory work, a small reference library, and a certain amount of apparatus. Most of this latter is inexpensive; the compound microscopes are the chief items. In some of the physiological work and particularly in the later work on plant types, these are indispensable—one for every two pupils, if the best results are to be obtained. This of course is a disputed point. There are those, called by their opponents the "cross-section botanists," who would put the main emphasis on the study of minute structure; and there are teachers who contend that a microscope is not necessary, that it gives pupils false notions, even that it is an actual

hindrance in the study of plant life. If the course in botany is to be descriptive, observational, superficial, the kind properly included in nature study, where the plant world is studied in its relation to man, then a microscope can be dispensed with. But if the course is to treat of the science of plant life, where the point of view is shifted and botany is "getting on in the world from the standpoint of a plant," then assuredly a compound microscope is needed. How can the pupils get a good idea of the plant at work without seeing stomata and root hairs, or gain any proper idea of a cell from a printed description? And why should not an intelligent boy or girl of fifteen use the microscope to get these ideas? In the present condition of elementary science these two kinds of botany must be taught in the high schools. As a recent writer in *SCHOOL SCIENCE* has said, it is strange that the high schools have not demanded that the foundations of botany be laid in the nature study courses in the grades. There is now a popular demand for such courses and the high schools should see that they are given. The gap between the eighth and ninth grades is recognized. The high schools have fixed this attention more on the college above than on the grades below with which the connection is of more vital importance. As the colleges set the pace for the high schools, let the high schools pass the help on down. There is perhaps no department in the secondary school which is getting so little preparation in the grades for its work as is science. This is a chance for teachers of science to give a good deal of help. Here is a plan which has been tried with success: The science teacher calls the grade teachers together and presents the subject; then together they formulate a course in nature study on the lines laid down by Dr. Hodge of Clark University, which shall have some organic connection with formal courses in science to follow. Until something like this is done, high school botany will be hardly worthy of the name of a science, and the teacher who is trying to follow the outline given by the Society of Plant Morphology and Physiology in *A Standard College Entrance Option in Botany*, is probably trying to build a structure which has no foundation.

FLIES AS CARRIERS OF BACTERIA.

BY EVA MAY SHOEMAKER AND ALVIN WAGGONER,

Students in the Eastern Illinois State Normal School.

A REVIEW.

SCHOOL SCIENCE has recently received for review a manuscript copy of an original laboratory study in elementary bacteriology, done last summer, by two students in the Eastern Illinois State Normal School. The students doing this work are at present juniors in that school, and, at the time they undertook the work, had received no more academic training than the average high school senior. Their problem was taken up in connection with the regular summer course in Public Hygiene, and was completed in three weeks, without interference with other school duties. Their solution of it is one of the most successful pieces of research work ever done by secondary students.

Their paper opens with a brief account of the nature and importance of bacteria and of the methods by which they may be grown and studied in the laboratory. This introduction is designed to familiarize the readers, unacquainted with bacteriology, with the methods used in their investigation. In it they describe the agar tube and the Petri dish, and show by colored sketches growth of bacteria in both.

Following this introduction, they state their problem, which was to "determine the part flies may play in the transmission of bacteria."

The method used to solve this problem was to allow flies to walk upon or eat of material containing an easily recognizable species of bacteria, and then cause them to walk across the surface of the agar in an open Petri dish. In order to accomplish this, it was necessary to construct an apparatus to control the movements of these insects. The apparatus used is shown in Plate VI. It consisted of a box divided into two compartments. In the end of the first compartment and across the top of the second were sliding glass windows, and in the partition between the two compartments, a small opening that could be closed by a door. On a shelf in the second compartment was placed an open Petri dish, and above

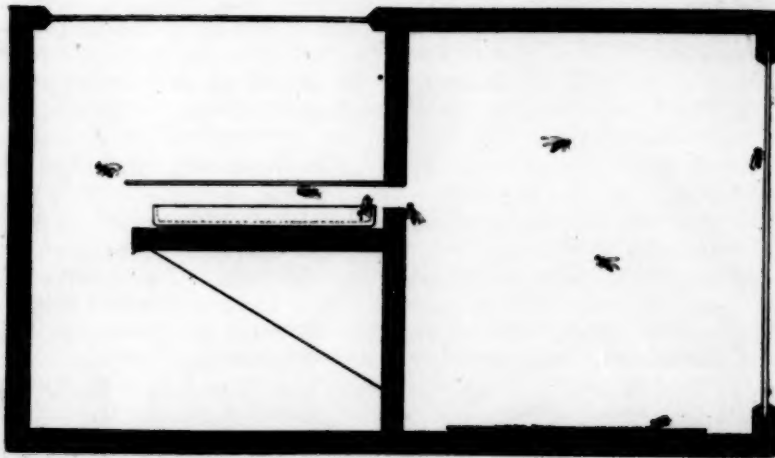
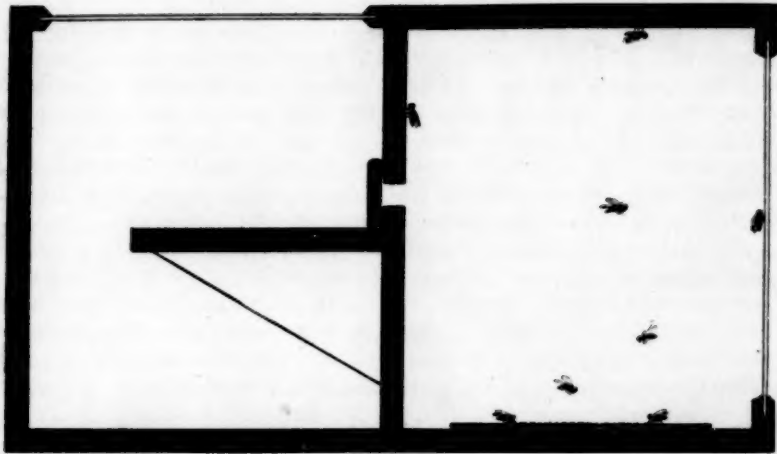


PLATE VI

it a pane of glass. On the floor of the first compartment was a plate on which infected material could be spread.

In using the apparatus a number of flies were put into the first compartment and allowed to remain there until several of them had been seen to light upon the material containing the bacteria. The door in the partition was then opened and the flies allowed to pass through. Their passage was hastened by darkening the first compartment. As the flies passed under the pane of glass, some of them walked on the agar in the Petri dish. The upper figure in Plate VI shows the flies in the first compartment before the door was opened. The lower figure shows them in the act of passing into the second compartment.

In the preliminary experiment, performed July 16, a yellow bacterium was used. Molasses mixed with a growth of this bacterium was spread on the plate and about a dozen flies were put into the apparatus. Half an hour later the door between the two compartments was opened and the flies allowed to pass through. In doing so six of them came in contact with the agar.

The Petri dish used in this experiment as it appeared a few days later, after the development of the colonies, is shown in their drawings. It contains over a hundred colonies of yellow bacteria.

In order to show that these colonies come from the germs exposed on the plate in the first compartment and not from other sources * * * * * the experiment was repeated with a second group of flies, but with no yellow bacteria in the first compartment. The petri dish from this second experiment * * * contains colonies of bacteria, as we should expect, since it was exposed to the open air for half an hour, but there is not a single yellow colony among them.

A more extensive series of experiments was performed on July 21. In this series four lots of flies were used. The first lot was put into the apparatus, the door was opened and they crossed the Petri dish, but they were not allowed to come in contact with the material containing bacteria. The flies in the second lot were allowed to walk upon a plate smeared with a culture of yellow bacteria; those in the third lot, upon a culture of red bacteria; and those in the fourth, upon a violet one.

The four dishes obtained from this experiment are shown in their figures. ,

The first dish contains colonies of air bacteria; but there is not a yellow, red, or violet one among them. The second dish contains more than a hundred yellow colonies, the third dish nearly

as many red ones, and the fourth a large number of violet ones. In each experiment the colonies that appeared in such great numbers are of the same kind of bacteria as those exposed on the plate over which the flies were allowed to walk.

From these experiments it is quite evident that the flies carried bacteria with them from the first compartment to the second. It might be argued, however, that the presence of bacteria on the plate in the first compartment was in itself sufficient to account for the appearance of colonies in the second compartment, that the bacteria might have been transmitted from the first compartment to the second by currents of air or by other means. To prove that this was not the case, the apparatus was prepared once more, exactly as in the above experiment—the Petri dish in place, the door between the two compartments open, and yellow bacteria spread on the plate as before—but this time no flies were put into the apparatus. The Petri dish was left exposed for more than an hour and then put away to develop, exactly as the others had been, but not a single colony of yellow bacteria appeared on it. * * * * The appearance of bacteria on the Petri dishes in the above experiments was due, therefore, directly to the presence of flies in the apparatus.

Having thus shown that flies are capable of carrying germs from one place to another when they have a chance to come in contact with material containing these organisms, we next inquired as to whether flies in nature actually do carry bacteria with them. To determine this, test tubes of agar were melted and then cooled to 40° C., a temperature a little above that of the human body. At this temperature the agar still remains liquid, but is not hot enough to kill bacteria. Flies were caught with sterile forceps and dropped into these tubes. The tubes were shaken for a minute or two and the agar then poured out into sterile Petri dishes. It is reasonable to suppose that if bacteria were present on the flies, some of them, at least, would be washed off by this process into the agar, where they would develop into colonies. The dishes obtained from this experiment varied greatly, but all contained colonies, the number ranging from fifty to several hundred.

Another way in which we showed that flies probably always carry bacteria about with them was by planting the legs of flies killed with hot forceps, on the surface of sterile agar. Around each leg rapidly growing colonies of bacteria always developed. * * * * An idea of the immense number of germs that a fly is capable of carrying was obtained by catching a fly that had been seen to walk on a culture of yellow bacteria, and "planting" it in agar, in the manner described above. A Petri dish

obtained by this means * * * * contained over two thousand colonies of yellow bacteria, showing that at least that number of germs were present on the fly's body.

As a result of their work, they have drawn the following conclusions:

1. Flies are capable of carrying bacteria from place to place, if they have a chance to come in contact with material containing these organisms.
2. Flies in nature probably always do carry bacteria with them.
3. They are able to carry them in surprisingly great numbers.

From the standpoint of public hygiene these conclusions are very significant; for, admitting that flies can carry harmless bacteria, there seems to be no reason why they cannot carry disease-producing bacteria as well. In fact, it has been a general belief among scientific men for a number of years that they are active agents in the transmission of many diseases.* Recent studies by Dr. L. O. Howard of the United States Department of Entomology, on the breeding habits of these insects,† furnishes good evidence that they may play an important role in the transmission of typhoid fever, dysentery and other intestinal troubles. It is probable that they can, and do, carry the germs of any disease in which they have an opportunity to come in contact with infected material.

They conclude their article by expressing their indebtedness to Mr. W. H. Maywaring of Johns Hopkins University, under whose direction their work was done, and to Mr. T. H. Briggs of the Normal Faculty, who has criticized their manuscript.

Their work is of value, not only on account of its scientific interest, but also because it points the way to a new field of effort open to secondary students—a field whose development would have an important influence on educational methods as well as on public health problems.

*Danger from Flies, *Nature*, Volume 29, p. 482.

† L. O. Howard, Flies and Typhoid Fever, *Pop. Sci. Mo.* Vol. 58, p. 249.

AN APPARATUS FOR ESTABLISHING ARCHIMEDES' PRINCIPLE.

BY GEORGE GEORGE.

Headmaster of the Sutherland Technical Institute, Longton, Staffs, England.

In Fig. 1 is shown a simple apparatus for establishing Archimedes' principle, measuring volumes, etc. It consists of an ordinary cylindrical lamp chimney *A*, about 5 cm. in diameter, fitted with a two-hole cork (a rubber stopper is preferable) through which pass two pieces of glass tubing *CD* and *E*, about 5 mm. in diameter. The tube *CD* (the index tube) is bent as shown and has scratched or etched around it at *D* a fine line. The short tube *E* is attached to a fine jet *F* by means of a piece of rubber tubing.

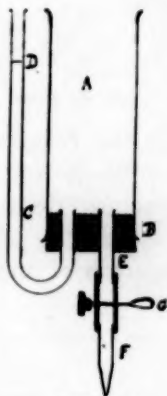


FIG. 1.

In using the apparatus to demonstrate Archimedes' principle, it is first filled with the liquid (*e. g.*, water) including the tubes *CD* and *EF*. *EF* is then closed with a spring clip and the liquid *gradually* run out until the *bottom* of the meniscus of the liquid coincides with the line at *D*. A convenient object (*e. g.*, a piece of brass) is placed in *A* and the liquid run out until the level again comes to *D*, and then weighed. The piece of brass having been previously weighed in air and then in the liquid, and the loss of weight noted, the two results are compared, when it is found that the "up-

thrust on a body immersed in a liquid is equal to the weight of the liquid displaced by the body." It has been found by experience that an ordinary boy or girl of 13 years of age is able to get results which have less than one per cent of error. The following figures are taken at random from a boy's note book:

(1) Weight of glass rod in air.....	=52.704 g.
(1) Weight of glass rod in air	=52.704 g.

Loss of weight in water	= 9.737 g.
(2) Weight of water displaced by glass rod.....	= 9.794 g.
Error = 9.794 - 9.737 = + 0.057 = + 0.6 per cent.	

The same apparatus has been found exceedingly useful for determining volumes, for example, in finding the relation between the volumes of a cylinder, cone, and sphere of the same base and height. The following results are taken from a school note book:

(1) Volume of cylinder	=49.1 cc.
(2) Volume of cone	=16.3 cc.
(3) Volume of sphere	=32.7 cc.

Therefore, vol. of cylinder : vol. of cone : vol. of sphere :: 3 : 1 : 2.

In using the apparatus the following precautions are to be observed: (1) The cork must fit well, hence a rubber stopper is to be preferred; (2) the apparatus must be free from grease; (3) the apparatus should be firmly clamped so that the level is not altered during the progress of an experiment.

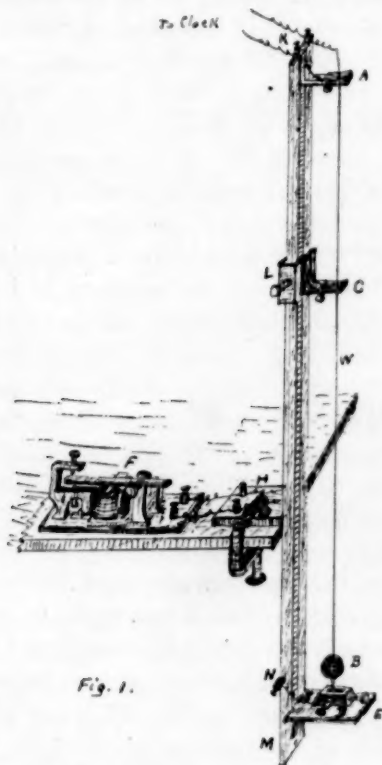
AN APPARATUS FOR THE PENDULUM PROBLEM.

BY H. N. CHUTE.

The purpose of this article is to describe a very simple and effective apparatus for the solution of the pendulum problem. With the usual apparatus and common methods, large errors always enter into the data in determining the time of a single vibration, on account of the difficulty of judging of coincidences. The device to be described obviates these difficulties and at the same time makes it possible for several instruments to be operated simultaneously. The writer had eight such pendulums in opera-

tion in his laboratory and sixteen students were working out the laws of the pendulum at the same time, and also obtaining data for the calculation of g .

The apparatus consists of a pine board, KM , (Fig. 1) 2.25 m. long and 15 cm. wide, with a bracket, H , attached about 75 cm. from one end, so that the frame may be clamped to the edge



of a table with the board in a vertical position. At the top end is a small metal bracket, A , to which is soldered a clamp for holding the pendulum wire. This clamp is made by slotting a short bar of brass and putting a machine screw through it. A rectangular frame, L , slides freely up and down the board, and by a wooden screw can be clamped at any required position. This frame carries a second bracket, C , exactly like the one at the

top. The pendulum slides through this second clamp. By means of this "slider," the length of the pendulum can be varied at pleasure, without interfering with any other adjustment. A shelf, *E*, at the lower end of the board supports a mercury contact, *D*, made of iron. It is of the form of a truncated wedge, the iron screw adjusts the mercury in the slot, and the binding-post is for connecting it to the binding-post, *N*, on the vertical board. Two binding-posts on the base, *H*, are for connecting the telegraph

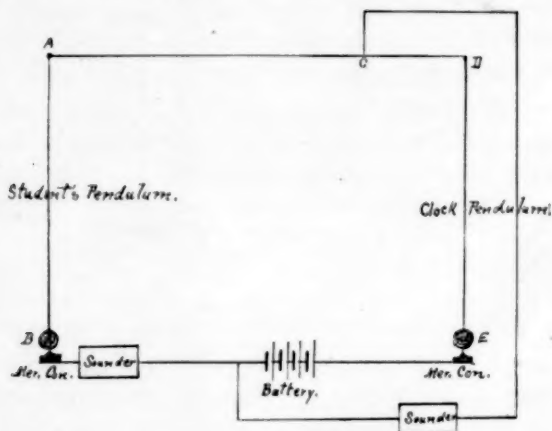


Fig. 2.

sounder, *F*. One of these posts is connected by wire to the post, *N*, the other is connected to a binding post at *K*, on top of the frame. The second on top of the frame is connected to the pendulum wire. The pendulum bob, *B*, is an iron or brass ball, about 2.5 cm. in diameter, supported by No. 28 brass wire. Projecting from the lower side of the ball is a piece of steel needle. When the pendulum is adjusted for work, the needle touches the mercury of the mercury contact. Two meter-rods, screwed to the support, furnish a scale for measuring the length of the pendulum.

A clock with a second's pendulum, provided with an electrical contact, is essential to complete the apparatus. A telegraph sounder is connected to the clock in the usual way. The pendulum is connected by the two binding-posts at the top to the clock, as shown in Fig. 2. From an examination of this figure, it will

be seen that the clock sounder responds at every stroke of the clock pendulum, but that the pendulum sounder responds only when the pendulums are passing through their respective mercury contacts simultaneously. It will also be noticed that the clock and pendulum are connected in series, and that the clock sounder is in shunt. It is also clear that any number of pendulums may be connected in series with the clock. A battery of about four cells (Leclanche) will be necessary to operate the apparatus.

To find the time of a single vibration, set the pendulum swinging through an arc of about 15 cm. length. Then, when the pendulum sounder speaks, one observer begins to count the vibrations of the pendulum while the other counts the click of the clock sounder. At the moment that the pendulum sounder announces the next coincidence, each observer writes down his count and begins again, being careful not to lose a count. This should continue for, perhaps, ten coincidences. Since the mercury contact has a sensible width, the intervals between coincidences may vary in length. A certain law of succession, however, will be found to obtain, and to get the correct time of a vibration it is necessary to determine the cycle of coincidences. When this is found, then divide the sum of the seconds by the sum of the pendulum vibrations comprised in the cycle, and the time of a single vibration is found to a high degree of accuracy.

The length of the pendulum is found by placing a carpenter's try-square against the frame, with its blade against the point of suspension and noting the reading of the meter-rod, then placing the try-square so that the blade rests against the top of the bob and noting the reading. The difference between these two readings, increased by the radius of the ball, gives a very close measurement of the length of the pendulum, but not exact, since the center of oscillation is slightly below the center of volume of the ball.

By moving the "slider," various lengths may be tried. It is also possible to test the effect of length of arc to a limited extent. With a very large arc, however, the mercury contact does not work well; on account of the quickness of passage of the needle-point through the mercury, the pendulum sounder may fail to respond.

DEMONSTRATION OF THE RELATION OF RADIANT ENERGY AND HEAT.

BY W. P. WHITE.

Cornell University, Ithaca, N. Y.

The differences between radiant energy and heat are so easy to understand and so fundamental, that their presentation would seem to be the most direct way to the mastery of the phenomena. The pupil who has been introduced to "radiant heat" may know the phenomena described in his textbook, but he can neither think nor read farther without confusion, unless he also learns a better way of looking at the facts. And as to saving the trouble of explaining to the beginner the nature of the invisible radiations, which is the only imaginable reason for teaching "radiant heat," we are only getting rid of one of the simplest, most important, most striking and most beautiful examples of scientific reasoning, possibly, to be found in any subject. One may well wonder what the object of studying Physics is supposed to be when such generalizations are passed over in favor of a narrowly empirical treatment of the facts.

The above remarks are justified by the attitude of some of our most popular textbooks, but are hardly necessary as an introduction to the subject of this short article—a piece of apparatus useful in emphasizing a few fundamental ideas, and perhaps most useful in physical Geography as a means of explaining, without a long digression into physics, the action of the sun in heating the earth without heating the air, and similar phenomena.

A test tube, a perforated rubber stopper, a small glass tube, and a drop of colored water make an air thermometer, which should not be too delicate. Inside of the test tube, running lengthwise, is put a piece of tin plate, bright on one side, blackened on the other, as long and as wide as can conveniently go in.

If the apparatus is held in a beam of sunlight, with the metal partition edge on, the light passes through. The whole tube is "filled" with light, but there is very little heat shown by the index. If the black side of the tin is turned toward the sun, the light is stopped, and heat is produced. The shadow cast by the tube shows the destruction of the light, whose energy is now heat. If the bright side of the tin is turned toward the sun, the

shadow appears, but the corresponding light is seen somewhere else, and there is still little heat produced. It is only when we destroy the light that we get its energy as heat.

A SIMPLE METHOD FOR MEASURING THE ELONGATION IN DETERMINING YOUNG'S MODULUS.

BY N. F. SMITH.

Professor of Physics, Olivet College

I have not seen the following method for measuring the stretch in a wire suggested in any of the laboratory manuals and it has given such satisfactory results in the hands of preparatory students that I venture to describe it to readers of *SCHOOL SCIENCE*.

The wire under experiment is rigidly attached by soldering to a heavy hook in the wall of the room and tension produced by a 15 kg. spring balance. Near the end the wire carries a light stiff index made of wood or metal which projects between the jaws of a micrometer caliper. The caliper is held tightly in a clamp rigidly attached to the table. By this means the elongation may be accurately measured to a hundredth of a millimeter and as a wire long enough to give a total elongation of a centimeter may easily be used, the error need not exceed 0.1 of one per cent. Of course the micrometer caliper could be used with the wire in a vertical position if desired.

Soot in City Atmosphere.—Some interesting particulars in regard to the amount of soot suspended in the atmosphere of Manchester, England, were deduced from observations made during a heavy snow-fall last winter. A sample of snow, which had been lying on the ground for ten days about three miles from the center of the city, was melted, and the dry residue weighed and analyzed. It was found to be equivalent to something over ten pounds per acre, or over three tons to the square mile for ten days, and consisted of 48.6 per cent of carbon, 6.9 per cent of grease, and 44.5 per cent of ash. A second sample, collected near the center of the city, disclosed about three times the amount mentioned above, or nearly one ton of soot per square mile per day. It is noteworthy that the soot of Manchester contains sufficient grease to make it stick tightly to the buildings or whatever other objects it falls upon.

Metrology.***METRIC SYSTEM EXERCISES.**

BY E. C. WOODRUFF.

Instructor in Physics, La Grange (Ill.) High School.

No novelty is claimed for these exercises. Their claim for recognition rests solely upon their concreteness. They constitute an attempt to furnish a class of chemistry pupils with a working knowledge of the metric system in a very concrete way, and at the same time to lead up to the features with which they will need to be most familiar. Many things are assumed or omitted, especially in exercises 9 to 12, such as the formal statement and proof of the laws involved, in the hope that thereby the definiteness and easy immediate applicability of the exercises will not be handicapped in any particular. Perhaps courses in laboratory physics, "concrete mathematics," or physiography might well be introduced by these same exercises.

To be committed to memory:

Metric tables of length, weight, and volume.

Nature of centigrade thermometer.

How to change Fahrenheit readings to Centigrade.

The number of inches in one meter.

The number of millimeters in one inch.

The number of pounds in one kilo.

The number of grams in one ounce.

The number of grams in a liter of water.

The number of ounces in a liter of water.

The number of ounces in a quart of water.

The number of grams in a liter of hydrogen.

The length of the edge of a cube of liter volume.

The results of each set of experiments are to be reported on 5x8 in. paper in tabulated form for filing.

The articles manufactured are to be labeled and handed in for samples when the experiments are finished.

The data from which the curves are drawn are to be reported separately. As fast as such data are handed in they will be

* Communications for the Department of Metrology should be sent to Rufus P. Williams, North Cambridge, Mass.

plotted in a large curve and put on the bulletin board. Then the pupil is to compare his curve with that representing the observations of the whole class.

Measurements of length.

- (1) (a) Cut a strip of heavy paper about 2x15 cm.

Mark in ink:

11 cm. on one edge, the last cm. in mm.

4 inches on the other edge, the last inch in eighths.

- (b) Measure in mm. to tenths of a mm.:

- (1) The edge of a leaf of the text.

Make three trials and average.

- (2) Measure with a meter stick:

- (a) in cm. to tenths of mm.

- (b) in inches to one-eightieth of an inch the length of your side of the laboratory table. Make three trials in each system.

Divide the average number of cm. by the average number of inches.

- (3) Estimate the dimensions of the inaccessible objects to be suggested to you.

Measurements of volume.

- (4) (a) Cut out a cubic centimeter from soft wood (or soap).

- (b) Make a cubic decimeter of stiff cardboard.

Measure each with your paper rule on all twelve edges.

Average the lengths, breadths, and widths.

Calculate the number of mm.³ in your cc., and the number of cc. in your dm.³ and the number of liters in your dm.³

- (5) Make the necessary measurements to determine:

- (a) The capacity of a hollow cylinder;

- (b) The volume of a rectangular prism;

- (c) The volume of a cylindrical prism.

Check each by using a graduate, (b) and (c) by immersion of the solid in the graduate partly filled.

- (b) The volume of the graduated portion of a burette. To get the diameter, measure a paper slip that will just fit.

Measurements of weight.

- (6) Run into a weighed beaker a known volume of water from a burette and determine the weight of the water. Take its temperature.

Calculate the weight of one c.c. of water at that temperature.

- (7) Weigh a measured length (10 cm. \pm) of a copper wire and calculate the length required to weigh a gram.

Measure the diameter of the wire by winding 10 turns around a pencil and measure the length of the coil.

Calculate the volume of a gram of the wire.

Calculate the number of grams that would have a c.c. for volume.

How much heavier is copper than water?

- (8) With a spring balance weigh a cube of lead in air and in water and subtract. (Read in grams and ounces.)

Determine the volume of the lead in c.c. by measurement.

What would be the weight of the same volume of water?

How does this compare numerically with the difference between the two weighings?

How much heavier is lead than water?

How could you have determined this without having measured the volume of the lead?

Verify by repeating the experiment with an irregularly shaped piece of lead.

Calculate from your weighings the number of grams in an ounce.

(To be continued.)

NOTE.

In England.—Matters must be progressing metricward rapidly with our British neighbors, if we take as an indication the statement of Sir Samuel Montagu, president of the Decimal Association, who recently observed: "*We have made more progress in the past seventeen weeks than in the previous seventeen years.*" In contrast to this advance, the following, according to an English paper, represents the progress of America towards a decimal system:

"Ten mills make one trust,
Ten trusts make one combine,
Ten combines make one merger,
Ten mergers make one magnate,
One magnate makes all the money."

R. P. W.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

BIOLOGY.

Double pitchers, found in some species of *Dischidia*, according to a review in the October number of the "Botanical Gazette," have been found to be a kind of living "flower pots." The plants are epiphytes and have xerophytic structure; their pitchers are morphologically leaves. Pearson's examinations showed that nine plants examined contained roots and soil in the outer pitchers. Ants, which make their homes in the pitchers, bring the earth. In one species the ants get a sweetish decomposition product.

A Biological Farm is the subject of an interesting paper in the October "Biological Bulletin," by Professor C. O. Whitman. It sets forth the need of thorough biological investigation. Not only dead organisms in the laboratory, but living organisms in all the different natural conditions of land, water, food, etc., should be studied in order to work out their development, hereditary, variation, etc. Whence comes the need of a tract of land, which may be designated as a "biological farm," with woods, meadow, fresh water, salt water or other conditions. It should be at a biological center, such as Woods Holl, Mass. Besides the benefits to science, there would doubtless be practical results in the improvement of domestic species.

Under *Habit Formation in the Green Crab*, Robert Yerkes describes simple and interesting experiments to determine how easily this animal learns to "profit by experience" and forms new habits (in October Biological Bulletin). To illustrate, a net was stretched across an aquarium; a piece of meat was placed directly opposite a crab, but on the other side of the net from him. A hole for the animal to pass through was made in the center of the screen. On first trial, the efforts of the crab to

gain the meat were much involved, but after repeated trials the path was much more easily found.

From another source the suggestion comes that here is a field of interesting and profitable experiments for all teachers, but especially for those who are not equipped with laboratories and apparatus.

Detroit Central High School.

BERNICE L. HAUG.

Of the *Field-book of American Wild Flowers*, by F. S. Matthews, Prof. Bessey says: The book deals with the flora of northeast North America only, and is not so comprehensive as its name would indicate, but its seventy-two families and numerous species are described quite non-technically and so well that any one should be able to identify every plant it includes. There are many excellent plates, some of which are colored. The book should serve the amateur botanist well and rouse, in others, interest in the common wild flowers.—(SCIENCE, January 23.)

Under recent studies of immunity, Professor Welch of the Johns Hopkins University, gives (Science, Nov. 21, 28.) a very interesting history of this most important line of investigation, or, as he says, "the first place in experimental medicine today is occupied by problems of immunity." He begins with the "Phagocytic theory" of Metschnikoff, the discovery of Pfeiffer that cholera germs are killed by peritoneal fluid and antitoxic immunity by Behring, pointing out that the body has the power to produce substances specially antagonistic to all sorts of foreign cells and cellular products;—"to every cellular group of an animal species there appears to correspond a specific cytotoxin."

So of the twofold bactericidal and cytolytic agents we may say that the living body possesses substances which may protect it by destruction of invaders or may injure it by destruction of its own cells according to the mates with which these substances are joined. The natural inquiry arises: "What is the physiological mechanism in the processes resulting in the production of antitoxins, cytolytins and similar bodies?" To this Ehrlich answers that the mechanism is one physiologically employed by the cells for the assimilation of food. These receptors are in the cells not for the purpose of linking poisons to the cells, but to seize certain food-stuffs, particularly the proteids; and the toxins, bacterial, and other foreign cellular substances, if capable of inducing the immunizing reaction, chance to have the requisite combining affinities for the food reception.

L. M.

PHYSICS.

Pressure of Illuminating Gas.—The increase of pressure with depth in gases is generally demonstrated where there is an aneroid available. It can also be shown by connecting a U-tube containing water to the illuminating gas pipes on different floors of a building. The results are perfectly definite and easy to observe with certainty, but are not what the average student, on first thought, would expect. The experiment thus becomes very instructive, and is a good deal more than a simple demonstration of the increase of pressure in air.

W. P. WHITE

The disturbances of the atmosphere have always been held by astronomers to be a fruitful cause of inaccuracy in observation. To remedy this (says Science, January 23), observatories have been built on mountain tops, in cold climates, and in other inconvenient places, for the sake of the clearer and stiller air obtained. Professor S. P. Langley, of the Smithsonian Institute, was led to believe that the greater part of the disturbance is caused by the movement of the air quite near the earth. Hitherto astronomers have tried to keep the air in the telescope tube as still possible; Prof. Langley's method, on the contrary, tells us to "churn" this air in the tube by some mechanical means. Strange as it may seem, this agitated air gives a "still image," as proved by photographs of artificial double stars taken at the end of a horizontal tube, 140 feet in length.

What will the explanation be?

L. M.

The Difference in the Expansion of Various Liquids may be very simply and conclusively shown by means of the following experiment. Two small flasks are fitted with one-hole rubber stoppers, through which pass glass tubes about 20 cm. long and of rather narrow bore. The flasks are filled brimming full, the one with water, the other with alcohol, and the stoppers inserted so as to make the liquids rise up in the tubes. By pulling the latter out or pushing them in, the levels of the liquids may be made the same, both the flasks being placed in a battery jar filled with cold water. When part of the cold water is replaced by hot water so as to raise the temperature of the liquids in the flasks, it will be seen that the level of the alcohol rises higher than that of the water. As a lecture experiment it is seen better by coloring the liquids with a little ink.

Reports of Meetings.

THE NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

The third meeting of the academic year was held in the Board Room, Board of Education Building, Park Row and 59th street, on Friday, January 30th, 1903, at 8:15 P. M.

The topic for the evening's discussion was "The Public Scientific Institutions and the School System." The first speaker was Dr. W. C. Bumpus, Director of the American Museum of Natural History, who called attention to the splendid equipment that the city of New York had provided for the education of the people in its public scientific institutions; that the relation that should exist between these institutions and the public school system, to be effective, should be brought about between the officers of the institutions and the officers of the public school system, but that there had been no special effort made to adopt a plan of active coöperation; that certain of the collections of the museums should be directly planned to meet the desires of the teachers; and that the American Museum of Natural History stood ready to aid in every way within its power; that the museum from its beginning had welcomed teachers and students at all times; that it had recently trained a young man to act as instructor; had provided an assembly room for the use of teachers accompanied by pupils; that it would arrange a library for nature study, and would like recommendations in regard to the purchase of special works on nature study, natural history, etc., from teachers; that courses of instruction had been given for many years; and that a series of guide leaflets had been issued at considerable expense for the express purpose of making the collections more immediately available for instruction purposes. He then indicated how certain exhibits might be arranged to cover a number of special subjects, and especially to bring the museum into use as a factor of public instruction in matters of current interest.

Dr. N. L. Britton, director-in-chief of the New York Botanical Gardens, came next on the program. He ably seconded Dr. Bumpus and gave the society an idea what was being done from the botanical point of view.

Speaking for the New York Botanical Garden, he remarked that

all the collections of the Garden are being developed with special reference to educational features. The Institution is open without charge to visitors every day in the year.

Over six thousand species of living plants are now available for study and examination under glass in the public conservatories; these for cultural and temperature conditions are first divided into (1) tropical species, and (2) warm temperate species. Each of these two main divisions are again grouped biologically in natural families, in so far as space, temperature and humidity conditions will permit; these make it necessary to arrange some families in two or more houses, and to prevent such a complete taxonomic sequence as can be worked out with hardy out-of-door plants. Orchids, for example, will be found in three different houses, run at different temperatures. A biological grouping, however, underlies the whole arrangement.

The tropical plants are grouped approximately as follows:

Ferns and fern allies in two houses.

Cycads in part of the large central house.

Palms and palm allies and bamboos in the large central house.

Orchids, for the most part, in the first house east of the central house.

Aroids and Bromeliads in the house just west of the central house, which also contains the pitcher plants of the Malay region (*Nepenthes*).

Amaryllids, Marantas, Liliaceae, and other Monocotyledonous families in one house.

Bananas and their relatives, plants of the ginger family and *Dracaenas* in the large house forming the northwestern corner of the range.

Grasses and sedges around the pool for water plants in a house near the southwestern corner of the range.

Choripetalous dicotyledons in two houses.

Gamopetalous dicotyledons in one house, and large specimens of both these groups in the large house containing the bananas.

The houses run as warm temperate houses contain representatives of a very large number of families; these are situated at the eastern corner of the range and at the western corner where two houses are given to succulent plants illustrating desert vegetation, including cactuses, stone-crops, agaves, aloes and their relatives.

The Herbaceous Garden, planted with hardy out-of-door perennial herbs and some annual species, is located southeast of the conservatories in a glade about eight acres in area, and here some 3,000 different species are grown, arranged in natural families in biological sequence from the ferns to the *Compositae*.

The Fruticetum or collection of shrubs is situated northeast of the Museum building on a plain of about fifteen acres and contains over

600 species of shrubs grouped in natural families. This tract is considerably disturbed at the present time, on account of road and path building operations, but the shrubs are easily accessible for examination.

The Arboretum site occupies nearly 130 acres on both sides of the Bronx river, the deciduous trees for most part on the east side of the river and the Conifers on the west side near the Herbaceous Garden and the Conservatories. Comparatively little work has yet been done in the planting of the Arboretum, but it will be taken up this year. Some 310 species have been brought together, but none of the planted trees are more than four or five years old. There are, however, over fifty species of trees native to the garden, and many of these have been labelled.

The Museums are very extensive, located in the basement and on the first and second floors of the Museum building. In the basement will be found a museum of fossil plants illustrating the different geological horizons from the oldest in which plant remains have been discovered to the most recent. The first floor contains the museum of economic botany, where many thousand specimens of plant products useful in the arts and manufacture are displayed. The second floor of the Museum building contains a carefully selected synoptic collection illustrating types of the natural families from the slime-moulds to the Compositae, illustrated not alone by specimens of the plants themselves, but by photographs and drawings; on this floor is also a mounted local herbarium illustrating the plants growing wild within 100 miles of New York City, arranged in swinging frames, so as to be readily consulted; and also a permanent microscopic exhibit, illustrating features in the structure of cryptogamic plants.

There is a large lecture hall in the basement of the Museum building capable of seating about 700 auditors, where public lectures are delivered in the spring and fall.

The upper floor of the Museum building contains the investigation rooms of the institution, its library and herbarium, to which access can be had by persons sufficiently trained in botany to make intelligent use of the equipment.

It will be seen that a vast amount of material has already been brought together, which lies open for the use of biology teachers and their students. Many of them are already utilizing the collections, and these will be increasingly used as they become better known and more completely installed, and as the education of teachers of biology and nature study progresses. It has been found necessary during the past year to double the case equipment of the Museum building, for the storage and display of the rapidly growing collections.

Any special assistance which the Garden can give, which does not interfere with administration and maintenance, will be most willingly rendered. Courses of lectures can be readily arranged if desired, and

visitors to the garden under guidance of members of its staff can also be arranged if requested by school superintendents, or other officers of the Department of Education, sufficient notice being given in advance to permit arrangements for meeting such parties to be made.

Some plant material has been furnished to teachers who have requested it from time to time, and if a definite scheme is worked out, showing just what sort of specimens are needed and the amount, this work may be greatly extended.

Dr. C. N. Townsend, Director of the New York Aquarium, then spoke somewhat as follows:

He had observed the great interest taken in the Aquarium by the large number of pupils who had visited the place with their teachers and thought that there must be some way of making the Aquarium more useful educationally.

He spoke of the establishment of a fish hatchery in the building which was not only interesting to the general public, but which would eventually become more or less a school of fish-culture for young men wishing to study this modern science so important to our fishery industries.

He called attention to the installation at the Aquarium of transparent labels which impart more information to the visitor than has been practicable with the labels employed there previously.

A collector has been appointed on the Aquarium staff to bring in large supplies of fishes and invertebrates, especially the latter, and, while these will be used in part for varying the collections exhibited at the Aquarium, there will be a large surplus of marine invertebrates available for biological work in the schools. He had already communicated with the Board of Education and found them interested in the matter, and willing to receive the material which the Director proposes keeping in abundance at the Aquarium, and deliver it to schools as needed.

He referred to the success attending the introduction of small fresh and salt water aquaria in the class rooms. These have been set up in a few schools and are highly appreciated both by the teachers and pupils. Mr. Townsend stated that the Aquarium was now prepared to assist the school board in establishing small aquaria in all the schools. He had suggested to the Board that the schools be provided with a few inexpensive jars which he would undertake to fill from time to time with a variety of living fresh and salt water forms from the Aquarium, and he is already doing this for a number of teachers who have provided jars at their own expense. As the total number of pupils who would have the opportunity of familiarizing themselves with the collections at the Aquarium would never be very large, he thought that the plan of bringing the Aquarium collections to the schools would be more far-reaching in its results. At the same time the interesting series of small aquarium jars in the laboratory of the Aquarium at the Battery

is being greatly increased so that teachers coming there with their classes will find living illustrations of many chapters in natural history that could not well be found elsewhere. The forenoons of Monday and Thursday have been set aside for the special benefit of teachers visiting the Aquarium with their classes. On these mornings the general public is excluded, and the Aquarium staff will be on duty to aid teachers in such ways as may be desirable. He thought that the existence of small aquaria in the schools would eventually arouse so much interest in nature study that it would lead to many pupils setting up small aquaria in their own homes, and they would find great pleasure and profit in collecting for them. He was of the opinion that some form of collecting was necessary in arousing and maintaining an interest in natural history, and thought that the seashore and the brooks offered perhaps the best of all collecting fields for amateurs as the supply of small marine and aquatic life is practically unlimited. He thought that while the study of ornithology was interesting and profitable, that it necessarily led to a considerable slaughter of birds for specimens and this was undesirable on account of the relationship between bird life and agriculture.

The announcement was made that a suitable library of books in marine and aquatic life was being established at the Aquarium which would be available for teachers and pupils at all times.

The New York Aquarium is not only the largest public aquarium in the world, but has by far the largest patronage by the public, its attendance averaging about 5,000 persons daily throughout the year. Such an institution, he believed, should be developed along educational lines as far as possible, and its resources would be placed at the disposal of the Board of Education as far as the funds at his disposal would allow.

The regular program was closed with an admirable address given by Dr. A. G. Mayer, Curator of the Division of Natural Science in the Brooklyn Museum. A brief abstract of Dr. Mayer's address follows:

The question before us is, how can the museum best aid the schools in the instruction of children between the ages of five and sixteen years.

The museum should, as far as possible, supplement the work which the schools are able to perform in education, by doing those things which the schools are unable to do, such as exhibiting objects which the schools cannot possess, or have no room for displaying. Such a museum should consist in a series of connected rooms, of moderate size, all highly attractive from an architectural standpoint, and in each of these rooms there should be displayed a limited number of excellent specimens accompanied by carefully written descriptive labels in simple English. Separate rooms might be devoted to the exhibition of models illustrating arts and trades, to History, Art, Geography and Ethnology, Zoölogy and Botany, Mineralogy and Geology, etc.

No large general collection should be exhibited, nor should any specimens find a place in such a museum on account of mere rarity or pecuniary value. Where possible the laws of nature should be illustrated by specimens which may be obtained in the immediate neighborhood of the city in which the museum is situated and complete local collections of insects, birds, mammals, minerals, etc., should be all which the museum should attempt in a general way.

A lecture room should exist in connection with such a museum, where lectures to school children should be given. Teachers should have the privilege of using this room whenever possible, and specimens should be brought to them for their use from the general museum. Books treating of the subjects illustrated in adjacent cases should be placed upon little tables provided with chairs for the comfort of readers and there should also be a library which should contain popular works of a general and reliable character.

The museum should lend small collections freely to schools and other educational institutions, and there should be at the museum a special officer whom we might designate as a "Museum Demonstrator", whose duties it should be to explain the laws which the specimens illustrate, and to render the purport of the museum clear. This officer should adapt his talks to the needs of the schools in the immediate vicinity of the museum. By coöperation with the schools, it would be possible for this officer to explain the main features of the collections to every child attending public schools of the city in the course of each year.

After the regular papers an informal discussion followed. Dr. A. P. Marble of the Board of Superintendents told of the need of coöperation of museums with the schools, and, how already steps had been taken by the Board of Education to render this coöperation possible in the form of loans and gifts of material and apparatus. Dr. Staubenmuller spoke eloquently in behalf of the teachers and students of the elementary schools. Several others, including members of the Board of Education, also spoke. The ultimate result of the discussion was that a motion was passed giving the incoming president the power to appoint a committee of five to enquire into, and, if they could, to fix the amount and degree of coöperation possible between the public scientific institutions and the city schools.

Before the meeting adjourned the following officers were elected for the ensuing year:

President—Mr. N. A. Kelly, School of Ethical Culture.

Vice President—Miss Kate B. Hixon, Morris High School.

Secretary—Mr. George W. Hunter, Jr., DeWitt Clinton High School.

Treasurer—Miss Ida Clendenin, Girls' High School, Brooklyn.

Reported by G. W. HUNTER, JR., Sec.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION.

Seventh Annual Meeting, Syracuse, December 30-31, 1902.

EARTH SCIENCE SECTION.

Abstract of paper on "What Should be Given as Laboratory Work in Physical Geography," by AMOS W. FARNHAM, State Normal School, Oswego, N. Y.:

The science of physical geography is based on facts obtained first hand from the earth itself. These facts have been gathered, recorded, and systematized, from the time of Job, down through the ages, to the present. The present way, the most satisfactory way, the ideal way to study physical geography is to study the earth itself. "Speak to the earth, and it shall teach thee." But human life is too short, and the story of the earth is too long for any one generation to read it in **Nature's book, recorded there by earth forces. Geography work done out of doors for purposes of study and discovery is called field geography.** Since conditions are not favorable for us to pursue this study with our classes in the field, or even alone with ourselves, we must then turn to the literature which scholars and teachers of geography have recorded for the faithful and the elect. The literature of geography includes the textbook of geography. Teaching physical geography by the use of literature alone, may be called the library method. The library and the field, each used independently, one of the other, are antipodal methods; but used together, each to interpret and supplement the other, they are then each the correlative of the other.

But there is a third means of gaining knowledge of physical geography, a means intermediate between the field and the library. It is the laboratory. Here is the place to test some of the statements learned in the library; to reduce to practice certain theories; to illustrate many facts; and to make the knowledge of geography experimental in a greater degree. The work of the laboratory employs the hand. No science teaching today leaves out this agent in the process of learning. Exactly what should be given in the laboratory depends upon the grade, the time assigned to the subject, the relative times given to atmosphere, water, land, and life, and, what concerns us most, the facilities and opportunities given us by the different institutions in which we work. But, whatever our limitations are, there is still room for much profitable laboratory work.

The first great geographic element is the world as a whole. The form of the earth is best represented by the globe. Its form may be proved by the problem of Eudoxus. The globe and blackboard diagrams may illustrate the phenomena of outgoing and incoming ships, a proof of the earth's figure and first cited by Strabo. Other well-known proofs may be illustrated.

The size of the earth may be determined by the problem of Eratosthenes.

Diagrams may be constructed to illustrate rotation, revolution, and the earth's position in the solar system. This work of necessity must be largely copied, but it will make the study clearer and impress it more deeply on the mind. Here comes in the exercise of what has been termed, "muscular memory."

The second great geographic element which we may consider for study in the laboratory is the atmosphere. The atmosphere cannot be studied with as great profit in the field nor the library, although field observation and library research should illustrate and direct laboratory work. We have noted that physical geography deals with the conditions of the atmosphere with regard to temperature, moisture, purity and movements. These conditions constitute the weather. Weather materials are general, abundant, and constant. They are always at hand, and never somewhere else when one wishes to use them. They may be studied by all grades, at any time of day, and on any day of the year. The youngest child in the school has some knowledge of the weather through his own experience, hence an interest in it. The oldest child in school can learn something more regarding it. The weather changing almost momentarily furnishes a new phase for every lesson. Monotony is not one of its qualities. The weather affects local industries, social appointments, and determines local pastimes. It is the stuff that climate is made of. A knowledge of local weather is necessary for the understanding of local climate; and local climate is the only means to an understanding of the climate of more remote regions. There is no more important geographic element than climate. "The climate of a region is the sum of its weather." Heat is the most important weather element. It determines the relative amount of moisture which the atmosphere is capable of containing. Heat and moisture determine the relative density of the atmosphere, and therefore its movement. The degree of heat or cold is measured by the thermometer. The moisture or humidity is measured by the hygrometer; amount of precipitation by the rain gauge; density, hence pressure, by the barometer; velocity of atmospheric movements, winds, by the anemometer; and the direction of the winds by the wind vane. These apparatuses, so far as the school may be provided with them, should be handled, and their construction and use studied by each member of the weather study class, so far as their age and attainments will permit. Here library work may be correlated. Pupils may be referred to biographical articles on Galileo, Fahrenheit, Torricelli and other noted scientists who have made valuable inventions to aid us in the study of the weather. The history of the Weather Bureau should have due consideration and its publications should be noted. Children in primary grades should make non-instrumental observations; in the grammar grades, elementary instrumental observations;

in high school grades, advanced instrumental observations, unless advanced weather study gives undue time to the atmosphere, which would be the case in schools having but twenty weeks for the whole study of physical geography. The teacher of physics and the teacher of physical geography could help each other greatly here by correlating their work.

Laboratory work on weather should include the observation and recording of minimum and maximum daily temperatures, diurnal range of temperature, average daily temperature. For January and June, pupils should observe and record the absolute maximum and absolute minimum temperatures, absolute monthly range of temperature, mean maximum and mean minimum temperatures, and mean monthly temperatures. Then determine mean annual temperature, mean minimum and mean maximum annual temperature, and mean annual range of temperature.

Similar work on atmospheric pressure, rainfall, etc., may be done and recorded.

Laboratory notes furnish material for class-room work, where the correlation of the direction of the wind and the pressure of the atmosphere may be made; also the direction of the wind and the temperature; direction of the wind and rainfall. In connection with government weather-maps, wind velocities and atmospheric pressures may be correlated; and cyclones and anticyclones in their relation to one another, and the local weather conditions determined by each, may be studied with marked interest. It will be realized by the geography teacher that no geographical element lends itself more easily to laboratory illustration than the weather; and that no element needs laboratory illustration more than the weather. In leaving this topic it may be added that Ward's *Practical Exercises in Elementary Meteorology* gives plain and valuable directions for laboratory work on weather study.

The laboratory work on streams and lakes should be done on the streams and lakes of the neighborhood after the actual study of them as field work.

In the field the stream and lake basins should be carefully considered, noting their approximate forms, comparative sizes, the direction of their length and breadth, and their boundaries regarded as water partings. Then should be noted the tributaries of the streams, the angle at which they enter, the trunk stream, and the inlets and outlets of the lake. Then the comparative heights of the banks of the stream and the shores of the lakes. The data gathered in the field should be carefully recorded in the observer's note-book. At a subsequent period in the class-room the pupils should examine diagrams of stream and lake drainage, found in any one of the latest half dozen works on physical geography, to learn the conventional lines, shadings, and color schemes used to represent streams, lakes, relief, water partings, and any other features that need to be represented in the diagrams. The pupils should not be

required to construct the diagrams to a close mathematical scale. "For the letter killeth, but the spirit giveth life." It is geography, not arithmetic, that is to be emphasized at this time.

The work on local drainage should be followed by a study of well selected U. S. Geographical Survey Maps, beginning with the quadrangle that includes the school site. In connection with this study, require the construction of a stream profile, from source to mouth, from data furnished by contour lines; also require the construction of a profile of a cross section of the stream basin. The quadrangle studied will suggest the laboratory work that may be profitably done.

By the use of tracing paper, maps of the oceans with their systems of currents and eddies may be constructed with profit. Such work gives greater definiteness of location and form, and fixes the facts in the memory.

After a careful study of the relief and drainage of continents, made from maps in actual relief, models of the same may be made in sand. After this practice, models may be made in pulp, which models may be preserved by the persons making them. I find that pupils enjoy coloring these pulp maps, using the color schemes found in their textbooks. Teachers will find help along this line in Maltby's *Map Modelling in Geography and History*, published by the Kelloggs. Also in Heffron's *Chalk Modelling*.

There are no better helps in the study of relief and drainage than are published by the Geologic Survey, a catalog of which may be had on application to the director. These map sheets cost but two cents a piece by the hundred, and a person may order a hundred different map sheets. A little book published by Henry Holt & Company, New York, entitled, *Governmental Maps for the Use of Schools*, is of practical help to the beginner. These maps furnish studies in the various plains as to their origin; plateaus, as to age; mountains as to the manner of formation; typical volcanoes; glacial formations; and the different classes of coasts. Sufficient data are given on each map for laboratory work, either in profile drawing or sand modelling.

The stereopticon may be considered as a supplement to field work; snap shots of the local geographic forms as laboratory-field work; but the preparation of the lantern slides is laboratory work, pure and simple. The stereopticon has become a necessary adjunct to the teaching of physical geography. Pictorial teaching is a strong factor in all teaching. The use of local views in the stereopticon makes unfamiliar views seem more real, and something more than mere pictures.

The sketch-picturing of geographic forms is legitimate laboratory work. These sketches often give the pupils geographic concepts more fully than oral descriptions could possibly give. Practice in sketching may be had from copying sketches found in Augsburg's *Easy Drawings*

for *Geography Classes*, published by the Kelloggs, also in Morton's *Chalk Illustrations for Geography Classes*, published by Flanagan.

It is believed that all of the laboratory work indicated in this paper is practical and helpful, although not a little of it is elementary. The work in topographic maps, however, may be done in the high schools and in all of the higher grades.

Each teacher of physical geography must determine the time and place, the character and amount, the relation and purpose of his laboratory exercises. Let him see to it, however, that he so determines. The omission of laboratory work is the omission of a prime factor of geography teaching. The laboratory: the field on one side, the library on the other; a trinity in a unity. And the teacher who does not believe in each fails to understand fully the purpose of physical geography in the plan of instruction.

Abstract of paper on "School Museums and Their Limitations," by RICHARD ELLSWORTH CALL, Curator of the Children's Museum, Brooklyn Institute of Arts and Sciences.

"Coöperation Between the Public School and the Public Museum" suggests a new line of reflection in pedagogy. Not long since no relation, no coöperation, was conceivable. The Museum pursued its way, collecting curios, bric-a-brac, natural history specimens, war relics from Shiloh, gun-stocks from Bunker Hill, fragments of corners from John Brown's monument, parts of New York's first customs House, et cetera, while the public school attended to geography, arithmetic, grammar, battles and similar things, each ignorant of the needs and plans of each other. Principals thought that they filled all requirements when the records were complete and the "excuses for absence" were properly filed. Teachers imagined their salaries fairly earned when they had learned the location of Dubuque or Kalamazoo, the length of the Niger, the exact position of magnetic north, the real home of the jaguar, whence comes Mocha coffee, and similar matters of little or no educational value. School boards made monthly or semi-annual visits, the city superintendent came and looked wise, the principal made his daily rounds, the teachers struggled with blue jays and owls, with iron-pyrites and malachite, with the seventeen-year cicada and the mole, and all thought Nature had been studied, understood, interpreted, and made a part of the life of the child!

It is only in recent years that the value of intimate association with Nature has been understood to be an educational factor. Plants and insects; earth, rock, mineral and soil have come to have a new significance in these later years. Museums have sprung into existence to foster these

interests and to make boys and girls think, and through thought to make them better. What is the relation of the school to these repositories of fact and specimens, these magazines of power—if rightly used. I can only suggest, not determine. What the *end* will be, the great body of active teachers alone can determine.

Perhaps if I suggest the plan the Museum I have the honor to represent attempts to develop I shall best tell you my own idea of a Museum. In the first place, the Children's Museum alone, in all the world, attempts to meet the child-mind and explain to it natural facts and natural forces. And after three years of attempt and experiment, we have only begun. In this Museum we seek coöperation. We do not always get it. In Greater New York a position in the public schools is, unfortunately, a life position. At once private study and research ends. The ambition of teachers reaches only a regular salary limit. To draw that salary with as little trouble and work as possible becomes the general ambition. So no attention is given to ideals, to innovations, to anything beyond a perfunctory accomplishment of the course of study. Nature, the whole-souled, generous Nature, which enlarges our conceptions of life, enriches our mentality, warms our hearts, makes life not a thing to be measured, but an impulse to be felt, comes in for small share of love or attention.

The Children's Museum has attempted to solve this problem for Brooklyn. To us come 12,000 to 13,000 young people a month. We have the aid and help of the progressive school principals and the school teachers. Many there are who receive our circulars and our bulletins, and into the waste basket they go without reading, without being handed to interested teachers, without a thought. But you will pardon me for saying that fossils have existed for a very long time in the history of the earth—and some of them bear an educational resemblance. So we are not discouraged; many help us if most do not.

Our plan is to seek schools unable, financially or scientifically, to collect museum material, or without a place to put it if secured. So we aim at supplementing the school room. Here at the Children's Museum are insects and life histories, fishes and collections showing their development, reptiles, crabs, mollusks, birds, mammals and plants, named in the histories, the readers, the geographies, of our young visitors. We "keep tab" on the requirements of the Board of Education in minerals, in geography, in zoölogy, in botany, and as fast as these gentlemen, themselves, seem to think they know what they want—or what the public wants—we supply it.

More than this. This Museum furnishes courses of lectures or half-hour talks, all given by trained assistants or trained naturalists. These supplement the work of the school room and add to the pleasure of the child. All are illustrated by specimens and lantern views and a wide range of school subjects is covered by these "half-hour talks." And

further, teachers come to us with classes and a special room, with lantern and operator, specimens, charts, trained assistants, is furnished on a half day's notice.

We coöperate whenever teachers will coöperate with us. We invite them. We furnish all materials. We even lecture to the classes they bring if they desire it. We ask their wants and try to meet them. We recognize that all schools cannot be museums. We supplement their work. If museums cannot do this, cannot meet the minds and needs of the young, they have no right to exist at the public expense. Coöperation between a recognized depository of natural history objects and the various departments of public instruction which may use them but not possess is essential to the life of both.

"It is method, not fact, which is sought in nature work. The facts all ought to be subordinated to the one thing which secures power to see and to express. It is the variety of nature that makes her so useful to the teacher in developing both these sides of our work. Here the teacher who knows nature rises above texts and schemes; above philosophies and theories; above concepts and appercepts, and all the other wonderfully intricate and sometimes meaningless trade terms of modern school teaching, and brings her boys and girls right up to nature's heart, and makes them glad that she, and not books, for the time takes their attention.

"Better leave nature severely alone rather than abuse her. She has no secrets which time and patience will not disclose both to the teacher who knows and who wishes to know. But she has niggard hands for those who seek to force her secrets and who pervert and abuse her disclosures. Don't measure the knowledge which your boys and girls possess by the questions and stated answers. Measure it rather by their ability to see and to reason in child-manner for this, and this alone, is the end at which nature work aims.

Now, to this end the school museum should be directed. This will mean, of course, local collections, first of all. They should be full and complete, so far as they go. A single life history of a beetle or a butterfly will answer as well as the life history of a dozen of each. The shells found in local ponds and streams, on the hillsides and under the logs and stones of the near-by farm, will serve as well as the rare and costly specimens from Ladoga or New Zealand. It is not rarity which alone interests the connoisseur or the expert or the original investigator, but typical forms which interest the educator. Not all birds but local birds, not all plants but local plants, not all soils but the soils of the near-by farm interest your pupil (and not all pupils at that), and that should be in the school museum. My experience in museums, which extends over a number of years, has taught me that a multiplicity of objects is not only confusing but is positively injurious to many child minds. In a large and richly endowed museum of my acquaintance is a beautiful

and nearly complete exhibition of North and Central American birds. Among these are practically all the 400 known species of humming birds. It is a very rich and very valuable scientific collection. But in this part of America we have the single species of *Trochilus*, the ruby-throated humming bird. It is the humming bird of our textbooks. A child with his classmates and teacher will visit this great museum. Those of you who know the child mind can well understand that no clear conception of the common humming bird can come to a mind confused with four hundred, or more, different objects of a related character. Instead of a clear-cut opinion or knowledge, a confused notion only is secured in the young mind. The school museum should remedy this evil—for educational evil it is—and supply only types. A hawk and an owl will suffice to illustrate the characters of birds of prey; a crow or a jay will answer as well as a hundred others; a heron or a crane will serve to show wading-birds; a duck or a goose the peculiar features of a swimming-bird.

Lastly, the school museum is not, or should not be, a research museum, but a place for illustration of commonplaces in natural science. The child is not an original investigator and should never be placed in the attitude of one. The world has learned a vast array of facts by hard knocks. Don't knock the child similarly! Let him "be the heir of all the ages." Let him see the finished products of nature, but let him reason about them, about evolution, and development, and phylogeny, and transmutation, and variation after he has reached mature years and learned to see; after he can discriminate between a cabbage and a clam; after he can tell the difference between an oyster and an owl.

The school museum, then, is of necessity small, but inclusive; its ideal is selection; its aim is training and observation.

Discussion of the preceding paper by PROFESSOR AMOS W. FARNHAM.

The school museum in by far too many schools is conspicuous because of its absence. And when it really has an existence, in a majority of cases, its limitations rather than its resources are most noticeable. We may safely say that the schools equipped with well furnished museums are comparatively few. That the museum is not found today in most schools is due in most cases to the school authorities rather than to the teachers. The crying need is for suitable room for collections. Teachers, pupils, patrons and their friends would aid in forming collections if proper provision were made for their preservation and use. Empty or partly filled shelves and cases invite specimens, and the invitations are sooner or later, usually sooner, accepted and responded to.

The purpose of the museum seems to be to furnish in a concrete form proper material to illustrate not only the teaching of natural science, natural history, and nature study, but the teaching of literature, general

history, and, in fact, almost every branch of school study. To accomplish its purpose, even in a modest way, the museum should be furnished with collections to illustrate the teaching of the great human industries; agriculture, grazing, lumbering, hunting and fishing, manufacturing, and commerce. These collections should include specimens of raw materials, specimens of manufactured articles in their different stages of completion, maps of regions where these industries are carried on for export trade, as the wheat regions of the Red River Valley, the seven leading corn states, the Pennsylvania coal region, etc.; also maps of the great industrial centers of main lines of travel, by land and by sea; pictorial illustrations of railway trains and ocean steamers, and of the different races in their homes to illustrate modes of living and climatic conditions; models of typical topographic forms; pictures and casts of works of art; and other unnumbered things that find legitimate places in the school museums.

But many things often find places in museums that are not legitimate; queer things, abnormal productions, objects that cannot be classified. The school museums should not harbor "any old thing" and so diminish its scientific value.

The interest in pedagogical studies has increased the demand for school museums, and made the teacher painfully aware of its limitations.

The museum often brings the field to the classes in geography, botany, geology, and nature study, when the classes cannot go to the field. Many museum specimens are bits of nature taken from their settings; but, with the aid of pictures, preferably the stereopticon, and with the aid of the library, their settings may be restored.

Every teacher may make a valuable collection of pictures, and then properly classify them for use in his own classes. He may have access to this nucleus of a museum, which, if well used, may be an entering wedge to something larger, more general, and more useful.

Question.

30. Where can I find the addresses of dealers in live animals, such as turtles, birds, guinea pigs, rats, white mice, frogs, etc.? A little while ago I wanted to get some frogs very much, but could not find the address of a dealer.